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Woodings et al.

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[54] **BLAST FURNACE TAP HOLE DRILL WITH CENTRALIZING DRILL ROD SUPPORT**

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[51] **Int. Cl.**[5] **C21C 5/48**

[52] **U.S. Cl.** **266/271**; 266/45

[58] **Field of Search** 266/45, 271, 272

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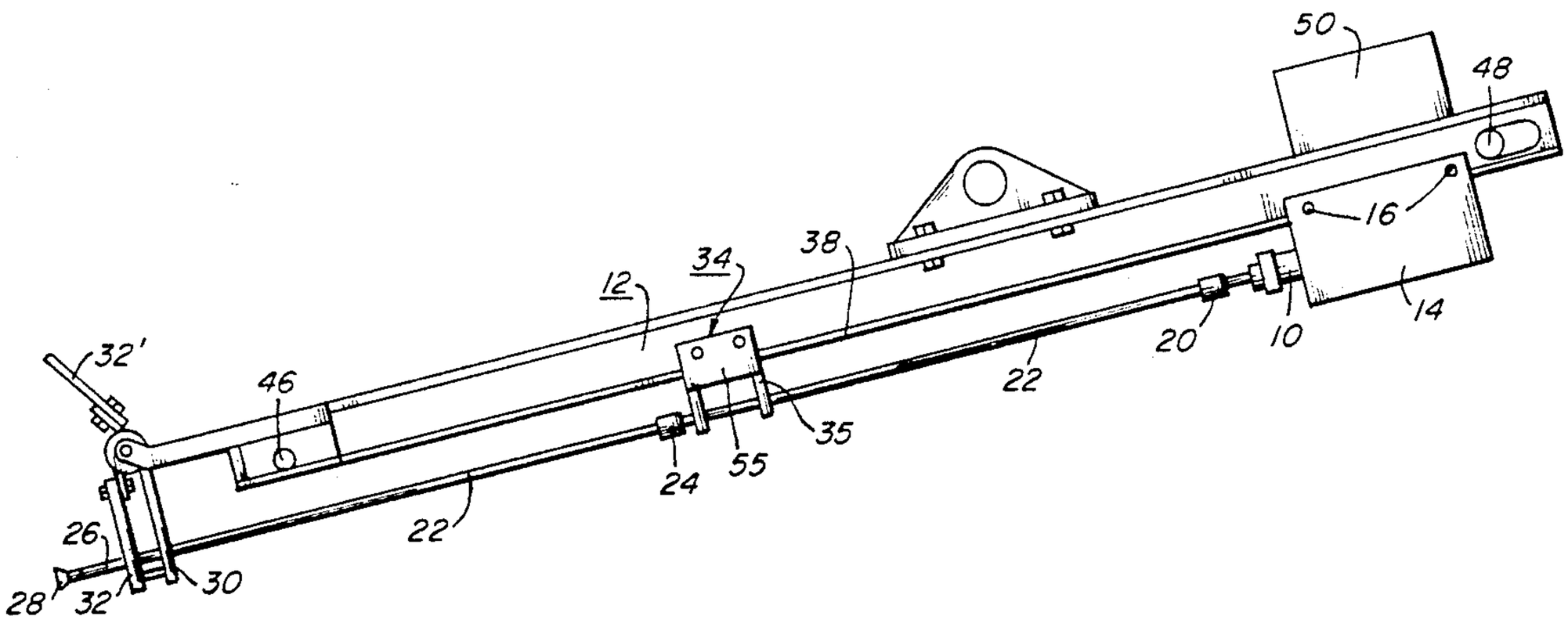
Attorney, Agent, or Firm—Forest C. Sexton

[57] **ABSTRACT**

A blast furnace tap hole drill is provided having an elongated feedshell which supports a percussion drill, drill rod assembly, and a centralizing drill rod support disposed between the percussion drill and a stationary forward end drill rod support, and a drive means for advancing the percussion drill and centralizing drill rod support in unison along the length of the feedshell such that the advancing motion of the centralizing drill rod support ceases as it nears the forward drill rod support without stopping the advancing motion of the percussion drill.

10 Claims, 3 Drawing Sheets



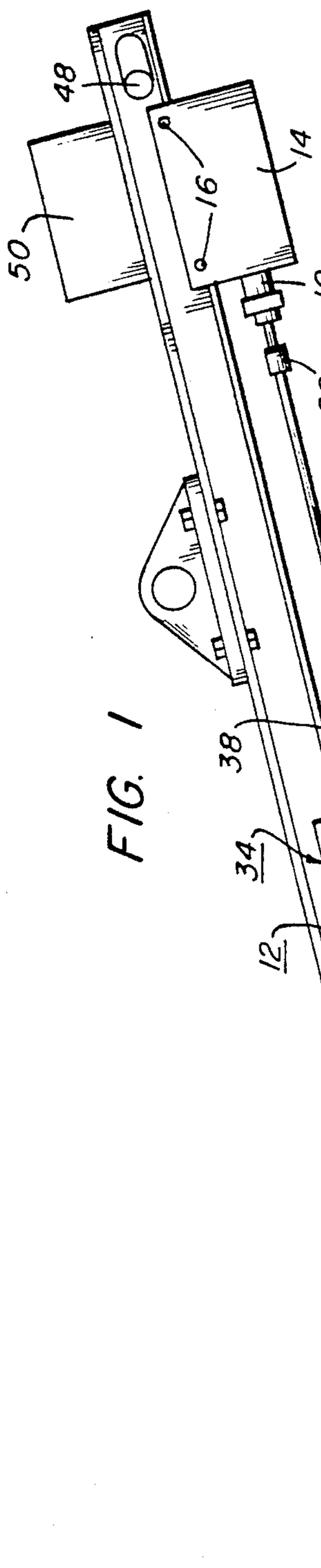

48
16
14
50
10
20
22
38
35
55
34
24
12
46
30
32'
26
32
28

FIG. 1

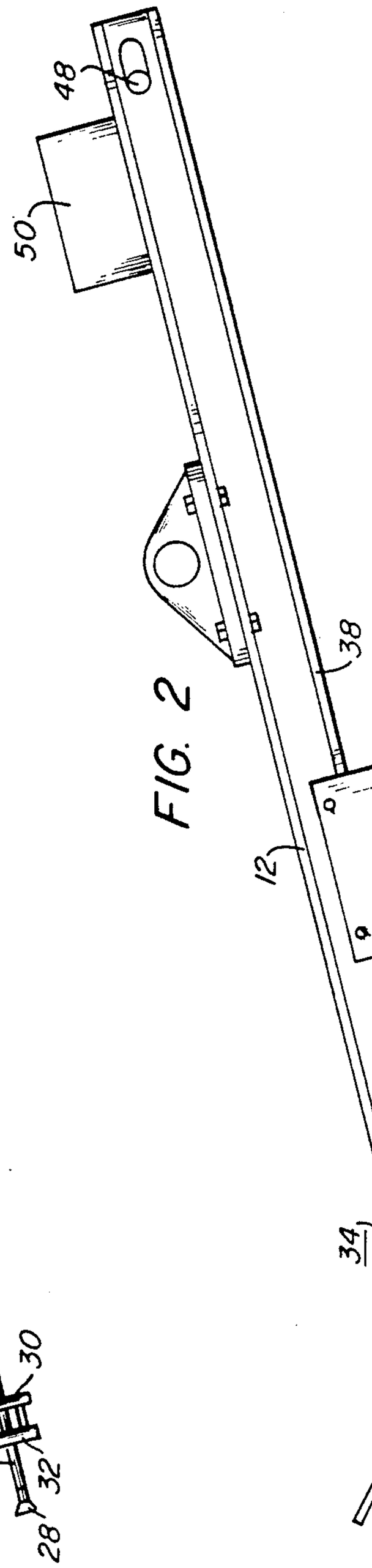

48
50
38
12
14
10
20
22
34
55
24

FIG. 2

FIG. 3

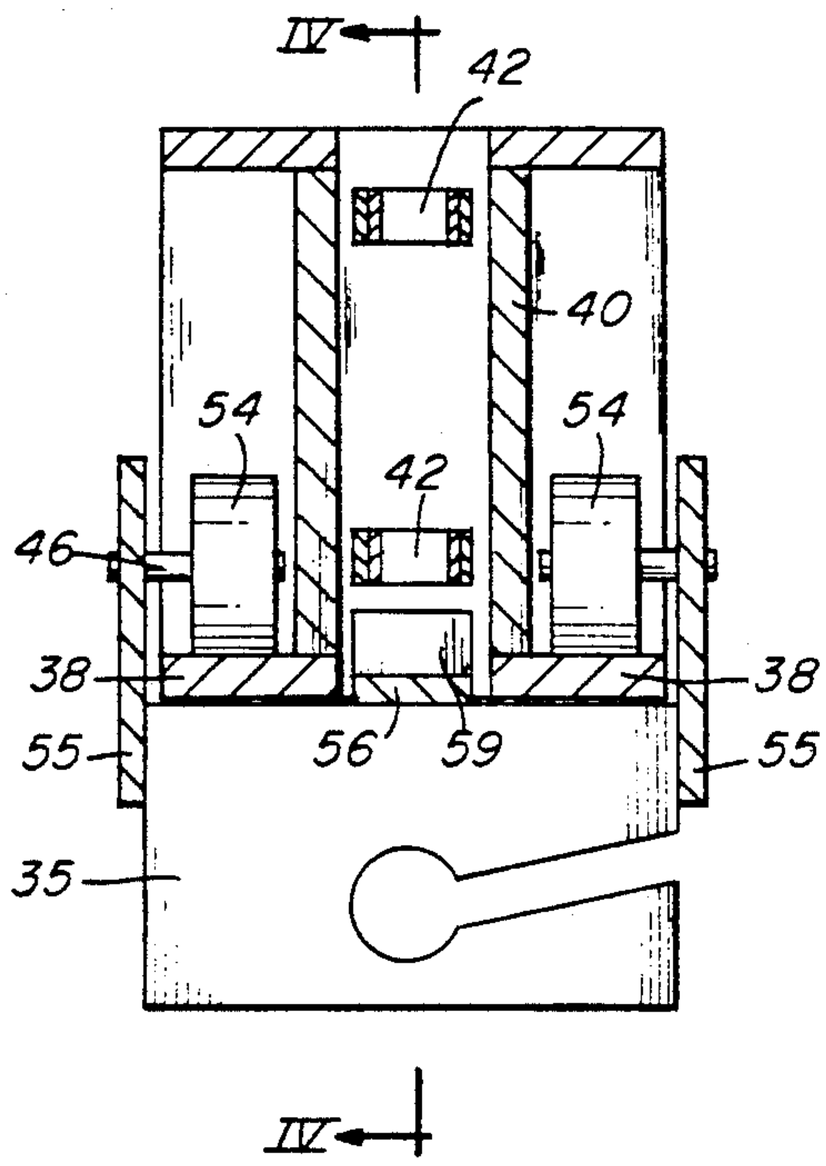


FIG. 4

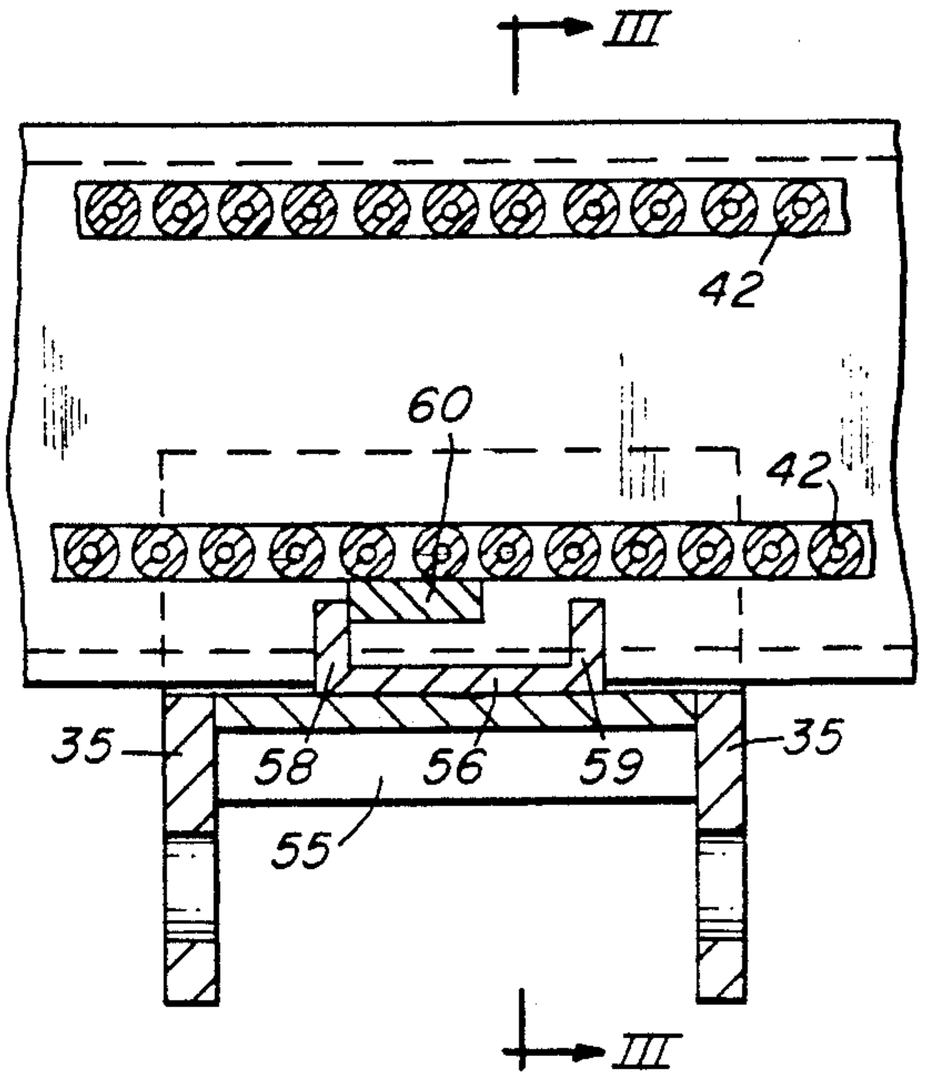


FIG. 5

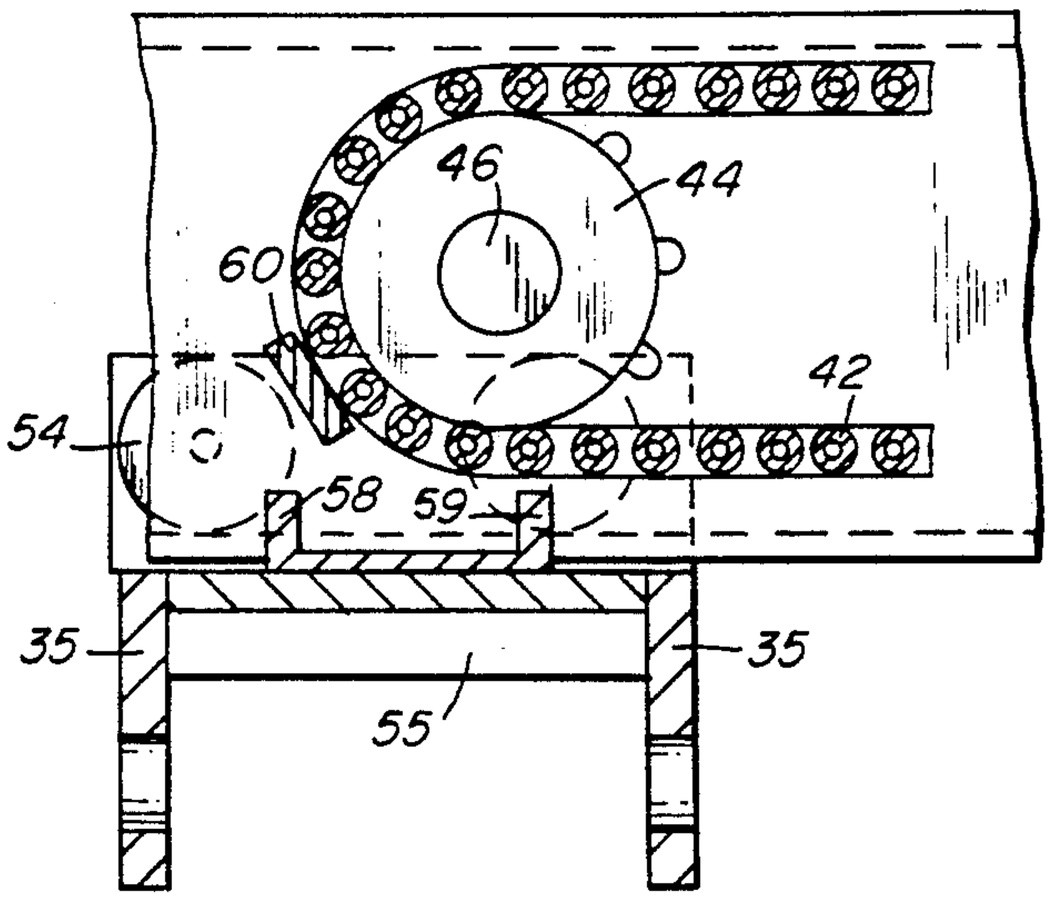


FIG. 6

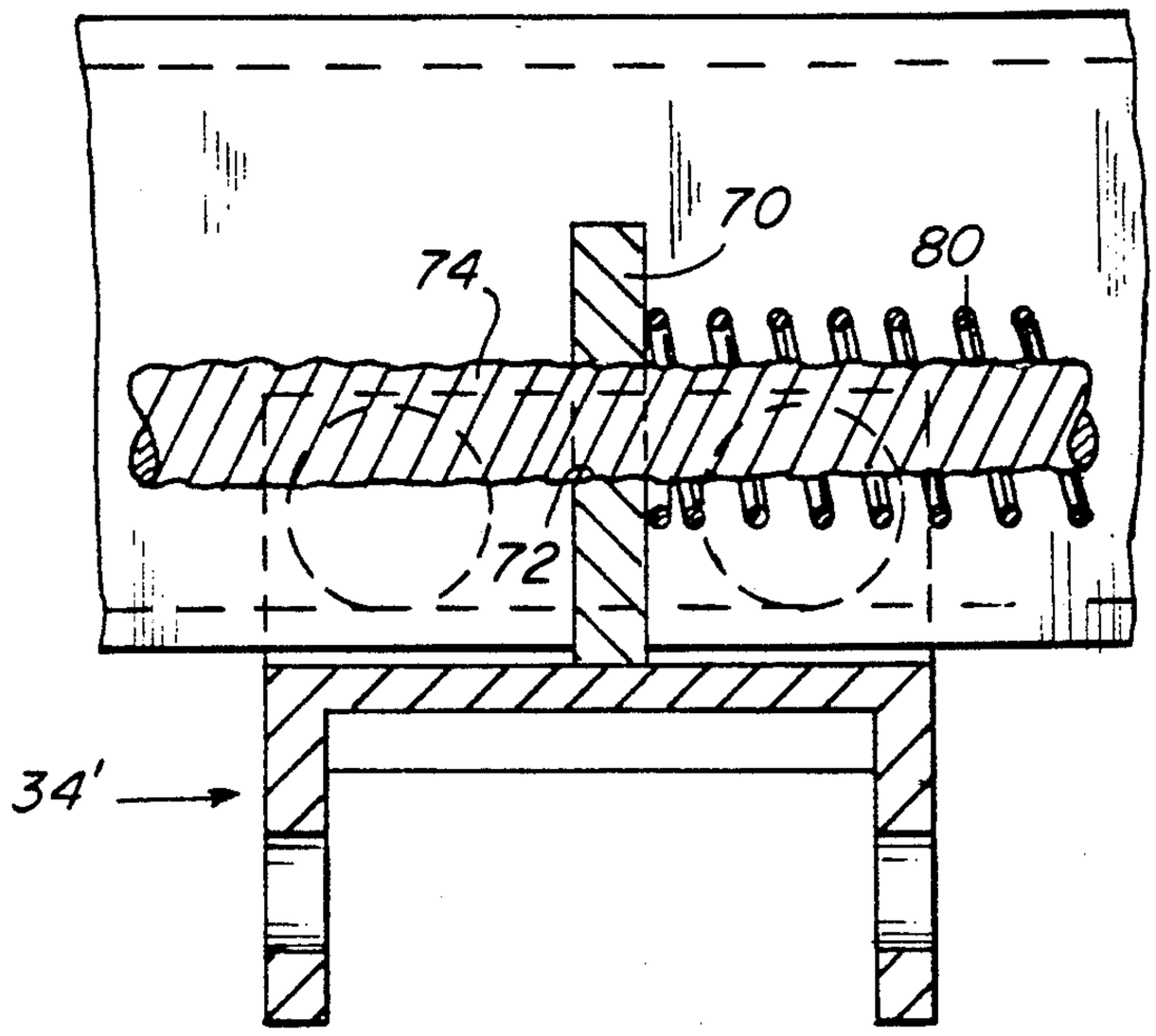
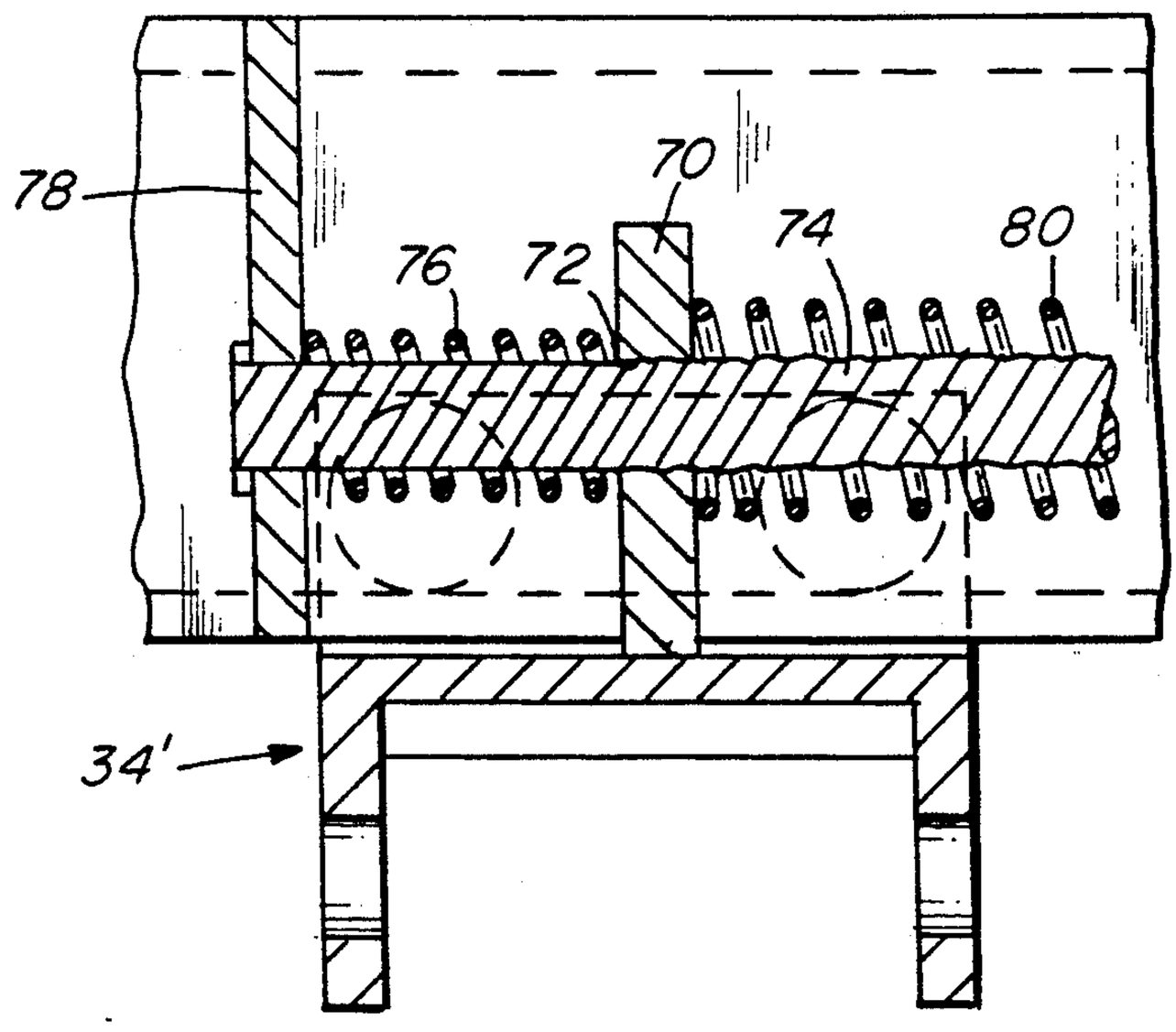


FIG. 7



BLAST FURNACE TAP HOLE DRILL WITH CENTRALIZING DRILL ROD SUPPORT

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to the art of opening blast furnace tap holes and to blast furnace tap hole drills, and more particularly to a new and improved blast furnace tap hole drill having a movable support means for supporting the drill rod between the movable percussion drill mechanism and the rod support at the forward end of the feed shell to thereby permit the use of multiple drill rod components.

2. Summary of the Prior Art

It is well known that the hearth of an iron blast furnace is provided with a tap hole, commonly referred to as a "iron notch", through which molten iron, usually referred to as "hot metal", is drawn off at periodic intervals during the blast furnace campaign. During a normal campaign, such tapping must be done on an average of five to twelve times daily as the blast furnace hearth becomes filled with molten iron and slag. After the blast furnace has been tapped; i.e., the molten hot metal and slag drained therefrom, the tap hole or iron notch is plugged with clay or "mud" which will harden and seal the tap hole until the next time the blast furnace is tapped.

In accordance with usual practices, a special drill is utilized to open a tap hole; i.e., drill a passageway through the hardened clay plugging the iron notch for the purposes of tapping the blast furnace. Such blast furnace tap hole drills are normally pneumatically or hydraulically operated rotary percussion drills comparable to the rock drills utilized in the mining industry. Such drills impart both a rotary and an impact force on an elongated drill rod having a rock drill bit at the end towards the iron notch.

The base support for the blast furnace tap hole drill is normally secured to the floor, a structural column, or some solid base structure and is provided with suitable linkage members and remote controls so that the blast furnace tap hole drill can be remotely operated from a safe distance away. Pursuant to such remote operation, the tap hole drill is operated to move the drill into the proper position for drilling the tap hole, then operated to drill the tap hole, and thereafter moved back away from the tap hole and heat of the emerging hot metal, where the drill can be serviced and prepared for the next tap.

To prepare the blast furnace tap hole drill for each succeeding tap, it is always necessary to replace the drill bit, if not the drill rod or a portion thereof. This is because the temperature of the blast furnace hot metal, being about 2700°–2800° F., severely erodes the drill bit after it drills through the clay plug and enters the bath of molten hot metal. In addition, once the tap hole is drilled the ferrostatic head of hot metal within the blast furnace will cause the hot metal to emerge through the tap hole around the drill bit and drill rod before the drill rod and bit can be withdrawn from the tap hole. Often times, the drill bit will not only be severely eroded but the portion remaining will virtually be "welded" to the end of the drill rod to which it had previously been removably attached. In such an event, it will be impossible to remove the drill bit from the drill rod to replace a new drill bit, and accordingly it then becomes necessary to replace the entire drill bit and adjoining drill rod or drill rod component to which it is welded.

To reduce the expense of replacing the entire drill rod and bit assembly, it has become common practice to utilize a drill rod extension, which is merely a removable end portion of the drill rod, typically from 18 to 30 inches in length, fitted between the elongated rearward portion of the drill rod and the drill bit. Therefore, when the drill bit becomes welded to the drill rod extension bar, or the extension bar otherwise damaged, the extension bar can be replaced without the need for replacing the entire drill rod assembly. Since the entire drill rod assembly is normally 11 to 15 feet in length, it is clear that replacement of an 18 to 30 inch extension bar is significantly less costly than replacement of a 11 to 15 foot drill rod. It often happens, however, that even the drill rod is damaged by the heat of the operation and in need of replacement. Since any damage to the drill rod is normally relatively close to the end attached to the extension bar, it is obvious that if the drill rod were to comprise two or more replaceable lengths, in addition to the extension bar, that additional savings could be achieved by merely replacing the forward portion of the drill rod.

Because of the exceptional length of the drill rod assembly, however, it has not been possible to utilize interconnections which are spaced significantly from one or the other of the supported ends. Specifically, if a conventional drill rod were to comprise two rods joined together at or near the mid-length, or even more than say 40 inches from an end support, the rotary and impacting forces acting thereon would tend to cause the rod to buckle at the interconnection and cause the drill bit to advance at an angle deviated from the drill angle intended. Such a deviated drill angle can cause damage to the iron notch as well as other complications in the tapping procedure which can not be tolerated. In fact, it is because of this buckling phenomenon that it is necessary to limit the length of the extension bar to no more than about 30 inches. If longer extension bars are utilized, the tendency for the drill rod assembly to buckle at the coupling interface becomes rather significant.

It has been appreciated that if the drill rod could be supported at or near the mid-length, that the tendency to buckle would be so significantly minimized, that the drill angle would not be adversely affected. However, most tapping procedures require that the percussion drill advance the drill bit by an amount almost equal to the length of the drill rod assembly. Therefore, the percussion drill advances throughout most of the length of the feedshell upon which it is advancing, brings it quite close to the forward rod support, and hence there is no place on the feedshell upon which a mid-length support can be positioned without it restricting the advancing motion of the percussion drill.

SUMMARY OF THE INVENTION

This invention is predicated upon the conception and development of a unique centralizing drill rod support which is mounted to the feedshell and designed for limited advancement in unison with the advancing motion of the percussion drill so that it will support the drill rod at some point between the percussion drill and forward support no matter to what position the percussion drill has advanced. Pursuant to the limited advancement, the forward motion of the centralizing drill rod support ceases as it approaches close to the stationary forward drill rod support without interfering with

the forward motion of the percussion drill. Because of this self-centering support between the percussion drill and the forward support, it thereby becomes possible to provide a two piece drill rod with an interconnection at or near the moving support because the centralizing drill rod support will significantly minimize any tendency of the drill rod to buckle at the interconnection. As a result of the use of the centralizing drill rod support and a two piece drill rod, only the forward portion of the drill rod will occasionally need replacement, and accordingly considerable cost savings can be achieved in maintenance of the blast furnace tap hole drill.

In addition to the above advantages, the centralizing drill rod support of this invention, by virtue of the added support, will also permit the use of smaller diameter drill rods. That is to say, because of the considerable length between the percussion drill and front support in prior art blast furnace tap hole drills, is had been necessary to provide drill rods of considerable diameter to avoid any sagging or whipping action which could cause the equipment to drill a tap hole deviated from a straight and true hole as intended. In supporting the drill rod between the percussion drill and front support, the centralizing rod support of this invention will also serve to prevent any sagging or whipping action, to thereby permit the use of smaller diameter drill rods, to further reduce the over-all cost of the operation.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a partial elevational view of a blast furnace tap hole drill in accordance with this invention, illustrating the feedshell assembly, percussion drill, drill rod assembly, and the centralizing drill rod support as positioned prior to drilling a tap hole.

FIG. **2** is identical to FIG. **1** except that it shows the relative positions of the same components at or near the most advanced position of the percussion drill as representative of the position where the drilling operation is concluded.

FIG. **3** is a cross-sectional end view of the feedshell through the mid-portion of the centralizing drill rod support rollably secured thereto, with the section taken at line III—III of FIG. **4**.

FIG. **4** is a partial cross-sectional side view of the feedshell and centralizing drill rod support in a rearward position as representative of its position in FIG. **1**, with the section taken at line IV—IV of FIG. **3**.

FIG. **5** is substantially identical to FIG. **4** except that the centralizing drill rod support is shown at its most advanced position after the drive bar has released engagement therewith as representative of its position in FIG. **2**.

FIG. **6**, is a cross-sectional side view comparable to FIG. **4** but illustrating a different embodiment based on a different drive means, illustrating the centralizing drill rod support as it would appear at its starting position.

FIG. **7** is substantially the same as FIG. **6** except that the centralizing drill rod support is shown at its most advanced position after the drive means has released engagement therewith.

DETAILED DESCRIPTION OF THE INVENTION

Reference to FIG. **1** will illustrate one embodiment of this invention in combination with a typical blast furnace tap hole drill feedshell and comprises a percussion drill **10** rollably or slidably mounted to the feedshell **12**. As shown, the percussion drill **10** is shrouded by a U-shaped protective steel plate **14** through which wheel axles **16** are mounted to thereby permit percussion drill **10** to move along the feedshell by virtue of wheels (not shown) rolling on the upper surface of the lower flanges **38**. A drill rod assembly is connected to the rotary tip of percussion drill **10** via coupling **20**. As further shown in FIG. **1**, the drill rod assembly comprised a drill rod **22** having a forward and rearward section joined together by coupling **24**, extension bar **26**, and drill bit **28**. Accordingly, the rearward end of the drill rod assembly is supported by percussion drill **10** at coupling **20**, while the forward end is supported by support plate **30** rigidly secured to the forward end of feedshell **12**. Also show in FIG. **1** is a splash plate **32** which is designed to shield rod support **30** from the blast furnace hot metal. Typically, a quick change splash plate **32'** is also provided.

But for the forward and rearward supports **30** and **20** described above, blast furnace tap hole drills of the prior art have not provided any other support for drill rod assembly. Pursuant to this invention, however, a centralizing drill rod support **34** is provided between support plate **30** and coupling **20**, which is supported by the adjacent percussion drill **10**.

As shown in FIGS. **1–5**, the feedshell **12** is normally a fabricated structure comprising primarily two fabricated steel channels **36** (FIG. **3**), each having a lower flanges **38**. Channels **36** are rigidly secured together with a space between the two flat back sides **40**. An endless drive chain **42** is mounted between the two steel channels **36** for rotation about a forward sprocket wheel **44** (FIG. **5**) and a rearward sprocket wheel (not shown). While the sprocket wheels are not visible in FIGS. **1** and **2**, forward and rear sprocket wheel axles **46** and **48** respectively are visible. As previously noted, percussion drill **10** is mounted onto steel channels **36** for rolling or sliding motion along the bottom surface thereof. Percussion drill **10** is also rigidly secured to one or more drive chain links (not shown) so that the percussion drill **10** can be advanced and retracted along feedshell **12** by proper activation of drive chain **42**. Therefore, a drive means **50**, such as a reversible hydraulic motor, is mounted on feedshell **12** to drive the drive chain **42** in either direction, and thereby drive the percussion drill **10** forward or backward along feedshell **12** as necessary to drill a tap hole and retract the drill bit when the tap hole has been drilled.

The crux of this invention resides in the centralizing drill rod support **34**, which like percussion drill **10**, is mounted to feedshell **12** for sliding or rolling motion along the lower surfaces of steel channels **38**. As shown, the drill rod support is provided by a paid of vertical plates **35**, each of which is provided with a slotted hole within which the drill rod **22** rests. While two such vertical plates **35** are utilized in the embodiment illustrated, it should be apparent that one such plate, or more than two, or even an elongated body, would be adequate for the purposes of this invention. As shown in FIG. **3**, inwardly facing wheels **54**, rotatably secured to wheel support plate **55**, are provided on the upper side of the centralizing drill rod support **34** for rolling along the flanges **38** of steel channels **36**, in much the same fashion as the percussion drill is mounted for rolling motion. Unlike percussion drill **10**, however, centralizing drill rod support **34** is not rigidly secured to drive chain **42**. Instead, the upper surface of centralizing drill rod support **34** is provided with a small channel section **56** with a forward flange **58** and a rearward flange **59** extending upwardly transverse to the direction of drive

chain motion, but not in contact with the drive chain **42**. A push bar **60** is rigidly secured across the lower side of a pair of chain links (FIG. **4**) which, when the percussion drill is retracted, is adapted to be positioned between the two flanges **58** and **59** on channel section **56**. Accordingly, when the lower expanse of drive chain **42** is moving in a forward direction and advancing percussion drill **10** in a forward direction, push bar **60** will be biased against the forward flange **58** of channel section **56** and therefore, also advance centralizing drill rod support **34** in unison with advancing percussion drill **10**. Therefore, centralizing drill rod support **34** will initially be advanced forwardly by the same degree as percussion drill **10**. It should be noted, however, that when push bar **60** reaches forward sprocket wheel **44**, it will rotate around the sprocket wheel **44** so that it is no longer in engagement with, and can no longer push against, forward flange **58**. At that point, therefore, the forward motion of centralizing drill rod support **34** will stop while percussion drill **10**, on the other hand, continues to advance.

After the tap hole has been drilled and the motion of drive chain **42** reversed for the purpose of retracting the percussion drill to withdraw the drill bit **28** from the blast furnace, push bar **60** will rotate around sprocket wheel **44** in the reverse direction. When push bar **60** reaches the lower horizontal expanse of the chain drive, it will engage and push against rear flange **59** on channel section **56**, to thereafter retract centralizing drill rod support **34** in unison with retracting percussion drill **10**.

In view of the above description, it should be apparent that in the starting position, centralizing drill rod support **34** is generally mid-way between the two drill rod end supports **30** and **20** of the drill rod assembly. As percussion drill **10** advances during a drilling operation, centralizing drill rod support **34** will advance in unison therewith so that the space between centralizing drill rod support **34** and forward support **30** progressively decreases, while the space between centralizing drill rod support **34** and rearward support **20** remains constant. When centralizing drill rod support **34** reaches a point under sprocket wheel **44**, however, its forward advance stops so that the distance between centralizing drill rod support **34** and forward support **30** remains constant while the distance between centralizing drill rod support **34** and rearward support **20**, afforded by percussion drill **10**, progressively diminishes. Therefore, while centralizing drill rod support **34** is not at all times equally spaced between the two end supports **20** and **30**, it does maintain a significant degree of centralizing drill rod support between the two end supports **20** and **30** so that it will support the mid-section of drill rod **22** to prevent any significant degree of buckling, even when the drill rod comprised two components joined together at or near the mid-length.

In view of the detailed embodiment of this invention as described above, it should be apparent that numerous other embodiments, variations, and modifications could be incorporated without departing from the spirit of the invention. While a specific mechanism design has been shown for pushing and releasing, and reengaging and pulling the centralizing drill rod support, it is apparent that other designs and embodiments could be utilized, and may in fact have to be utilized with differing blast furnace tap hole drill designs. For example, a drive means other than a drive chain will of course necessitate a modification based on whatever drive means is utilized. If the drive means were a worm gear, for example, the same principle could be utilized if a means were provided at the forward end of the worm gear for disengaging and releasing the centralizing drill rod support from the drive means to limit its forward motion without limiting the forward motion of the percussion drill. FIGS. **6** and **7** are illustrative of such an embodiment where a worm gear is utilized as the drive means to advance both the percussion drill (not shown) and centralizing drill rod support **34'**. In this embodiment, centralizing drill rod support **34'** is provided with a single plate **70** extending upwardly transverse to the axis of worm gear **74**, and having a geared hole **72** therethrough which mates with the gears of worm gear **74**. Accordingly, rotation of worm gear **74** will advance the centralizing drill rod support **34'** in unison with the advancing percussion drill. When plate **70** reaches a point where the gearing in hole **72** disengages from the gearing of the worm gear **74**, as depicted in FIG. **7**, its further advance will be stopped by a first compression spring **76** which will be biased between a front plate **78** and plate **70** on centralizing drill rod support **34'**, as a second compression spring **80**, extending between plate **70** and the percussion drill, is progressively compressed until such time as the forward motion of the percussion drill is stopped. Upon reverse rotation of worm gear **74**, second compression spring **80** will prevent plate **70** from being threaded onto worm gear **74** until such time second compression spring **80** is fully extended. At that point, first compression spring **76** will bias plate **70** sufficiently against the gearing on worm gear **74** to cause centralizing drill rod support to be re-threaded thereto and retracted by the worm gear **74**. Obviously, the biasing forces of second compression spring **80** must be sufficiently greater than those of first compression spring **76** to prevent premature retraction of centralizing drill rod support **34'**.

In addition to the above modified embodiments, it should be appreciated that the essential feature of the invention is that the centralizing drill rod support be advanced during a drilling operation as described to prevent it from limiting the advancing motion of the percussion drill while maintaining a support between percussion drill and the forward drill rod support. The advantage to be gained, of course, is to prevent any tendency for the drill rod to buckle during the drilling operation, particularly if a two piece drill rod, or a smaller diameter drill rod are used. Therefore, the supporting feature is not essential after the tap hole has been drilled or during the reverse, withdrawal operation. Therefore, the centralizing drill rod support could be returned manually after withdrawal of the percussion drill if desired. In the first above-described embodiment, this could be done by eliminating rear flange **59** from centralizing drill rod support **34**. In the second above-described embodiment, this could be done by eliminating at least the first compression spring **76**. In either event, the centralizing drill rod support would not be returned to its original starting position in unison with return of the percussion drill **10**, but could be returned manually merely by rearwardly hand pushing the centralizing drill rod support to its starting position. While such a manual return could prolong the time necessary to recondition the drill, such a practice may be desirable to some operators in facilitating installation of new drill rod components. Indeed, it would require very little effort to manually return the centralizing drill rod support to its starting position.

It should be further appreciated that the apparatus of this invention could even be incorporated into drill assemblies other than blast furnace tap hole drill, such as rock drill; for example, for purposes of achieving comparable benefits. Since conventional rock drill rods are not subject to frequent damage as a result of exposure to molten hot metal, however, there would be less benefit in using drill rod in multiple sections or thinner diameters. The primary advantage of this invention, therefore, is appreciated primarily with regard to blast furnace tap hole drills.

What is claimed is:

1. A drill assembly comprising an elongated feedshell supporting a percussion drill and an elongated drill rod assembly attached to the percussion drill, whereby said feedshell supports said drill rod assembly at a forward support disposed away from the drill rod, a centralizing drill rod support attached to said feedshell between said forward support and said percussion drill, a drive means for advancing said percussion drill and said centralizing drill rod support along the length of said feedshell as necessary to perform a drilling operation, release means for releasing said centralizing drill rod support from said drive means when said centralizing drill rod support nears said forward drill rod support to stop its forward motion without stopping the forward motion of said percussion drill.

2. A drill assembly according to claim **1** in which said drive means both advances and retracts said percussion drill and said centralizing drill rod support.

3. A drill assembly according to claim **1** in which said drive means comprises a continuous drive chain rotatable about a forward sprocket wheel, said percussion drill attached to said drive chain, and said release means comprises a push means attached to said drive chain adapted to engage and push said centralizing drill rod support until said push means revolves about said forward sprocket wheel.

4. A drill assembly according to claim **3** in which said drive chain is reversible and adapted to return said percussion drill and said centralizing drill rod support to a starting position.

5. A drill assembly according to claim **4** in which said push means is adapted to re-engage and push said centralizing drill rod support upon reverse activation.

6. A drill assembly according to claim **1** in which said drive means comprises a worm gear rotatably geared to said percussion drill and said centralizing drill rod support, and said release means comprises an ungeared portion of said worm gear at the forward end thereof adapted to unthread itself from said centralizing drill rod support to stop its forward motion without stopping the forward motion of said percussion drill.

7. A drill assembly according to claim **6** in which said worm gear is reversible and adapted to return said percussion drill and said centralizing drill rod support to a starting position.

8. A drill rod assembly according to claim **1** wherein said drill rod assembly is a blast furnace tap hole drill.

9. A blast furnace tap hole drill comprising an elongated feedshell supporting a percussion drill and an elongated drill rod assembly attached to said percussion drill, support means attached to said feedshell adapted to support said drill rod assembly at a position disposed away from said percussion drill, a centralizing drill rod support attached to said feedshell between said support means and said percussion drill, a drive chain rotatable about a forward sprocket wheel for advancing and retracting said percussion drill along the length of said feedshell as necessary to perform a drilling operation, push means on said drive chain for engaging and pushing said centralizing drill rod support to advance said centralizing drill rod support in unison with said percussion drill until said push means revolves about said sprocket wheel and thereby ceases to push said centralizing drill rod support to stop its advancing motion without stopping the advancing motion of said percussion drill.

10. A blast furnace tap hole drill according to claim **9** in which said push means is adapted to re-engage said centralizing drill rod support when it is activated in the reverse direction to thereby return both the percussion drill and centralizing drill rod support to a starting position.

* * * * *